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TERRAIN, HYDROGRAPHY, CLIMATE, AND VEGETATION OF NORTH ITALY

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Basic information on physical conditions in North Italy, including surface configuration, river regimen, irrigation, drainage, flood control, climate, and vegetation.

20 December 1943

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1400.1 NORTH ITALY

I. TERRAIN, HYDROGRAPHY, CLIMATE, VEGETATION

A. Statement of Problem

Certain basic physical facts concerning the terrain, the drainage or hydrography, and the climate of North Italy are important to anyone who must direct military operations or who must plan and carry out the government of occupied territory. These facts are set forth briefly in the following pages. North Italy, as considered in this report, includes the compartimenti of Piemonte, Lombardia, Venezia Tridentina, Veneto, Venezia Giulia e Zara, Liguria, and Emilia.

B. Description of Existing Conditions

1. Terrain. North Italy centers around the broad Po Plain which opens eastward to the Adriatic Sea and is bordered on the north, west, and south by high mountains of the Alps and Apennine chains. (Figures I-1, and I-2.) On the northeast the Po Plain merges into the Venetian Plain, which at its eastern limit abuts against Istria. Much the greater part of North Italy is flat plains or rugged mountains. There are few areas of low hilly land.

a. Mountain rim. The Apennines, geographically a continuation of the Alps, cut diagonally across the northern end of the Italian peninsula and form a barrier between the Po Plain and central Italy. Highest elevations are found in the part of the range southwest of Bologna. The general upland level becomes lower toward the west.

Communication routes across the Apennines follow the river valleys, most of which trend northeast-southwest across the range. These do not all provide easy routes, however, and railroad lines across the Apennines pass through numerous tunnel one between Grizzana and Vernio being more than 12 miles long. Many valleys are without roads; other valleys that provide natural routes for roads leading into the mountains end abruptly in steep valley heads.

Landslides and other mass-movements of soil and rock are common in the Northern Apennines. Clayey materials are widespre and where clayey soil absorbs water from prolonged rains the ground may move as a semi-fluid (viscous) mass over the drier subsoil. Saturated clay may also act as a lubricating layer, permitting the sliding of overlying beds of rock. Certain limey clays (marls) locally abundant, weather into flaky fragments on exposure to air. When absorbing water these flaky clays swell a may displace overlying rock layers, which then slide on the visc clay. Other landslides are induced by stream undercutting of th steep valley walls.

The Alps extend from the Gulf of Genoa northward and eastward to Istria. In Liguria, the mountains are 4000-5600 fee high and descend steeply to the sea. Southward drainage is shor and in deep steep-walled canyons. Northern slopes are more gentle, and the tributaries of the Po are longer and flow in bro valleys. Giovi Pass, 1549 feet elevation, north of Genoa (Genov and Cadibona Pass, 1427 feet elevation, west of Savona offer relatively good natural routes from the Po Plain to the coast.

Northward in Piemonte and Lombardia the Alps are higher and contain glaciers and snow-capped peaks (Fig. I-1). The foothills are penetrated by many great valleys which offer good access to the high mountain passes. West of the Brenner Pass, only three standard rail routes cross the Alps, each by means of a tunnel through the divide.

East of the Adige Valley, in the Dolomite Alps and in Istria, limestone is the commonest bedrock and the surface is characterized by irregular limestone peaks and plateaus, sink holes, and an absence of surface water.

b. Po Plain and Venetian Plain. The Po Plain, originally an arm of the Adriatic Sea, is an almost featureless plain that slopes gently away from the bordering mountains. Most notable breaks in the plain are the Monferrato Hills, east of Turin (Torino), and the Monti Berici and Euganean Hills that rise abruptly from the valley floor near Verona and Padua (Padova). Areas of rolling hill country developed on glacial moraines extend out from the mouths of the larger Alpine valleys. Bordering the Apennines and parts of the Alpine front is a belt of high ground, cut sharply by streams.

For sources of additional information see list at end of Hydrography Section.)

2. Hydrography. The many rivers in different parts of North Italy differ widely in regimen according to the source of their water. Both the Alps and the Apennines receive heavy precipitation, and in the Alps temperatures are sufficiently low to maintain extensive snow fields and glaciers. Maximum runoff

of the Alpine streams comes at the time when the greatest melting of snow and ice overlaps the end of the spring rains. In the Apennine rivers, maximum runoff comes in the fall at the time of maximum rainfall. The Alpine rivers are the larger and more regular streams, partly on account of the many moraine-dammed lakes that constitute large natural reservoirs and serve to equalize the stream flow. The Apennine rivers are intermittent, of uncertain flow, and subject to flash floods following periods of heavy rain.

a. Drainage net. Problems of runoff in North Italy fall into five regional groups (see Figures I-1, I-2).

i. Streams draining to the Gulf of Venice between the Brenta River and Istria. The streams from the Brenta River eastward drain directly into the Gulf of Venice, and are torrential. They are not controlled by lakes or glaciers. Their upper courses are in steep-walled valleys and descend steeply to the plains. After emerging from the mountains the streams flow generally in broad braided channels. Maximum discharge is in early summer and the minimum shortly thereafter, in July and August. Sudden high floods are uncommon, but high-water stages are frequent.

ii. Istria and the Carso Plateau. Istria and the Carso Plateau, at the eastern side of the Gulf of Venice, are limestone regions where surface water is scarce because drainage is largely underground.

iii. Po and its tributaries. The Po River, heading in the Piedmont Alps at an elevation of 6000 feet, drops 5000

feet in the first 20 miles of its course, but falls only 1000 feet in the remaining 260 miles airline distance to the Adriatic.

The left affluents of the Po originate in the Alps and have their highest waters in spring and early summer (May and June) and a secondary peak in autumn.

The right affluents, those originating in the Apennines, are shorter. They have their maximum flow in autumn and are low and often dry in summer. However, the largest floods in proportion to area come from the Apennine tributaries.

Floods on the Po River itself are uncommon, but unusually high stages may occur when summer rains coincide with high water from the melting snow.

Volume of the Po

(in cubic meters per second, 1 cubic meter = 220 Imperial Gallons)

	Max. flow	Annual average	Min. flow
Turin	1090 (May)	149	37 (Sept.)
Piacenza	11200 (May)	973	271 (Sept.)
Casalmaggiore	9900 (Nov.)	1280	300 (Apr.)
Ostiglia	9130 (Nov.)	1460	274 (Aug.)
Pontelagoscuro	8850 (May)	1570	380 (Aug.)

Floods of the Po

(Floods are considered here as heights above normal in percentages by month for a period of 120 years.)

Jan..... 3.2%	May.....15.2%	Sept..... 4.8%
Feb..... 2.4%	June.....15.8%	Oct.....18.9%
Mar..... 4.3%	July..... 1.1%	Nov.....15.8%
Apr..... 8.1%	Aug..... 2.1%	Dec..... 8.2%

iv. Apennine-Adriatic Drainage. The rivers of the Apennine-Adriatic drainage have their sources in the Apennines and empty into the Adriatic Sea. Their upper courses are steep

and entrenched, while the lower courses flow through narrow alluvial valleys. The streams are torrential and subject to sudden but brief floods during the autumn. Maximum flows are in autumn, and also during the time of spring thaws in the higher mountain areas.

v. Streams entering Gulf of Genoa. The streams entering the Gulf of Genoa are short, have steep gradients, and flow in steep-walled canyons or narrow valleys. Their flow is intermittent and subject to sudden floods of short duration during the winter rainy season. In flood stage these rivers carry much silt.

b. Canals and Drainage Ditches. Since ancient times the people of North Italy have gradually reclaimed large areas of marsh and of lands subject to flooding along the lower reaches of the Po tributaries and along the Po itself (Figure I-3). Other areas, particularly in the terrace regions closer to the mountain have been made productive through irrigation. So widespread have been these land-improvement practices that the general appearance of the plains, especially in Veneto and Emilia, today has been compared to that of Holland with its numerous ditches and canals.

The irregular and torrential character of many Italian watercourses, the low elevation and flatness of the plain, the impermeability of the soils, and possibly also changes in shore lines have resulted in poor drainage conditions and occasional floodings over large areas in the Po Plain and the lower delta region. The conditions of these lands are varied: Some of those along the sea coast are salt flats, some are marshes,

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NORTHERN ITALY, PHYSICAL

FIGURE I-1

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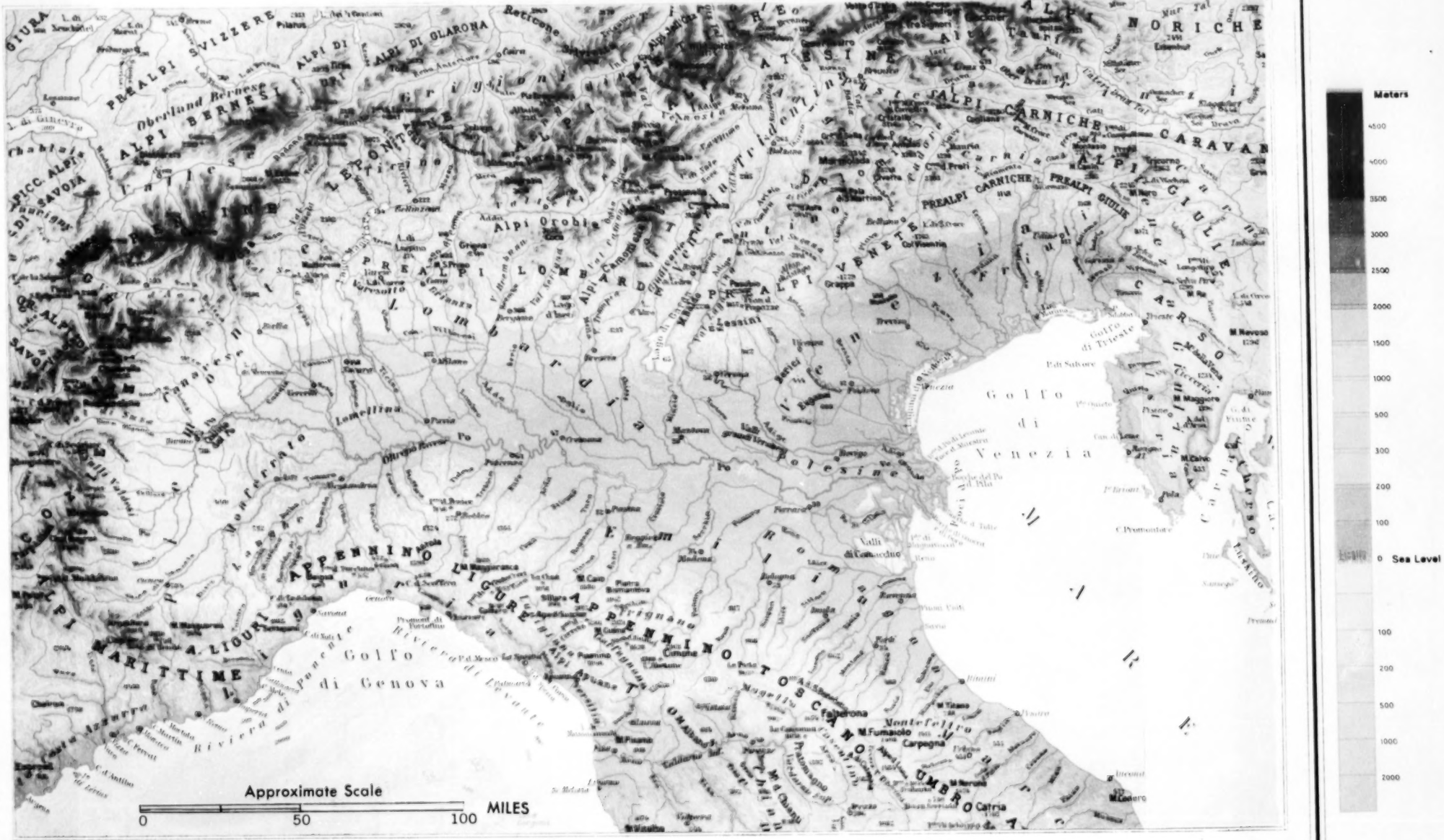

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FIGURE I-2

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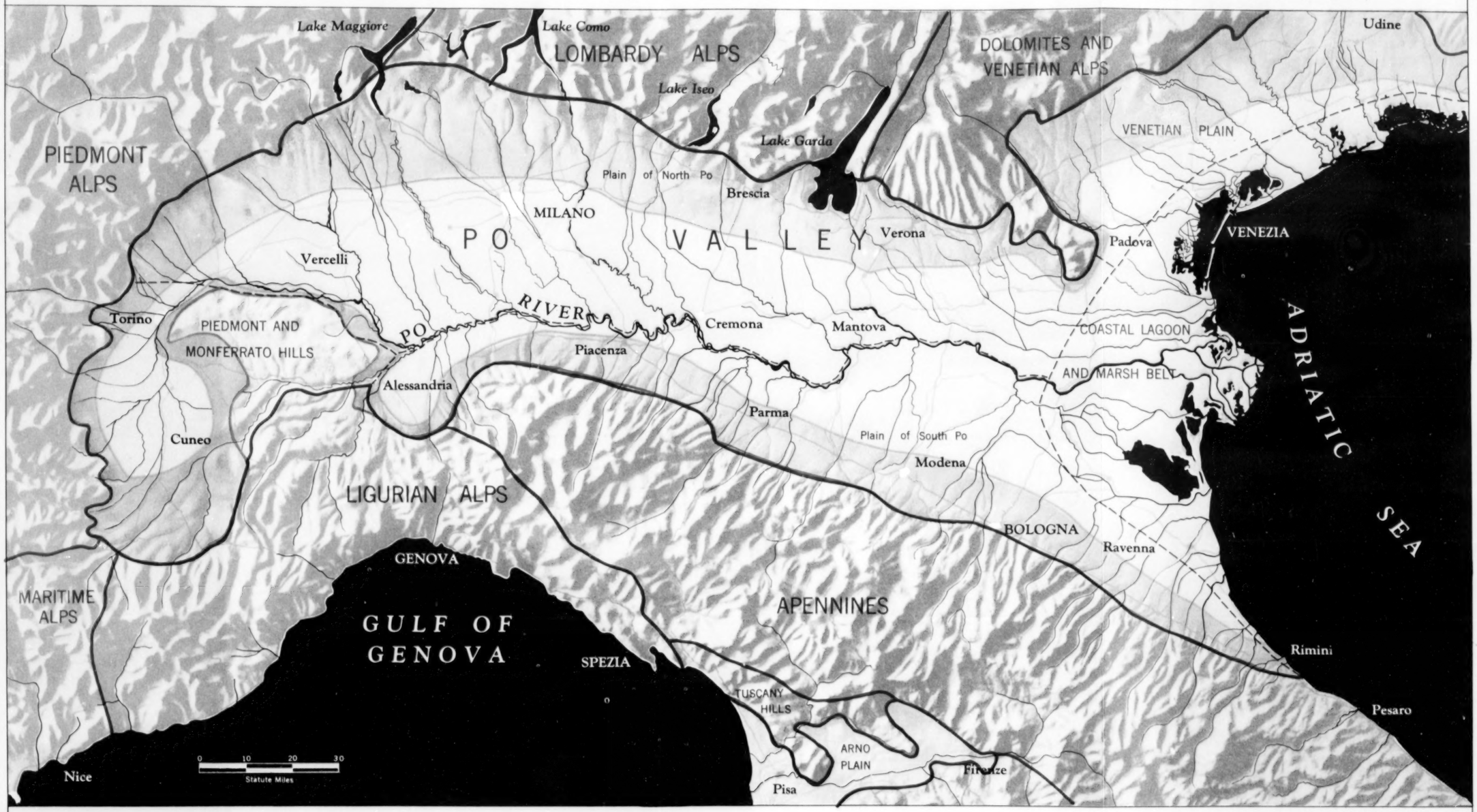
NORTHERN ITALY: TERRAIN



TERRAIN TYPES: Low Moist River Plains; Dissected River Terraces and Piedmont Slopes; Mountains and Hills

MAP NO. 2877
6 DECEMBER 1943

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some are poor grasslands subject to flooding, and some are arable lands. From the middle Po Plain to the Adriatic the needs of the country change. In the middle Po Plain, irrigation is the main requisite. Nearer the Adriatic the lands need irrigation in summer and drainage in the winter and spring. Close to the coast only drainage is required.

1. Irrigation canals. The irrigation system of the plains of North Italy is one of the most highly developed in the world (Fig. I-3).

In the North Po Plain (Fig. I-2) the belt of dry permeable and rather infertile gravelly soil extends from Piemonte to eastern Veneto. This belt, consisting of dissected terraces and gravel fans, is largely cultivated to mixed farming. Southward toward the Po River the sand and gravel deposits give way to silts and loams. Along the line of junction rise innumerable springs, the fontanili, which occupy a band about 6 miles wide north of Milan (Milano) increasing toward the east. In general, the high, dry, sand and gravel terraces along the mountain front are unsuitable for irrigation because the rivers are too far below the level of the plain for their water to be diverted economically. Some of the more northerly canals run north of the line of fontanili, however, and much of the southern part of the dry zone has been brought into the irrigation system.

The irrigated zone is largely south of the line of fontanili. Canals, some of them constructed in the middle ages, carry water to millions of acres. Most of the ditches bordering the fields are inconspicuous. The plain is flat but fields are

bordered by scattered trees.

Somewhat similar belts of land are found in the South Po Plain (Fig. I-2). On the terrace lands close to the mountain front only scanty supplies of water are available for irrigation, as the streams coming from the Apennines are small and usually dry in summer. Works completed in the last 15 years permit irrigation of some of this area.

Along the River Po the irrigated zone gives way to a zone requiring drainage. Although irrigation is practiced, provision must also be made for carrying away surplus water. In some parts of the Plain, as between the Adige and Reno Rivers, some of the dikes and ditches date back to classical times.

In the Coastal Lagoon and Marsh Belt (Fig. I-2) drainage works are more recent. Dunes line the coast, which is backed by a belt of low marshy country and water-logged lands. Much of the area in the immediate vicinity of the Po Delta is below sea-level and is being reclaimed by drainage and the natural process of silting. Higher flat ground, a few feet above sea level, is found to the west. Even this land requires a close net-work of drainage canals because the water table is very close below the surface. (For further information on irrigation see section 1400.2 of this report.)

ii. Navigation canals. Inland waterways, both canals and canalized rivers, are well developed for barge traffic. (For information on navigation canals see section 1400.10 of this report.)

iii. Flood-control systems. Extensive flood-control systems have been installed in the central and lower Po Plain.

Protection is especially necessary in the area south of the Po as the area lacks natural lakes and permanent snowfields to aid in regulating the flow of the streams.

The Po and several of the other large rivers have built up their beds from deposits of mud and silt and now run above the general level of the plain. Natural levees help to confine the flood waters, and man-made embankments or levees now back up the natural levees at weak points. Where more than one embankment has been built, the banks farther from the stream are lower than the main one. Other protective works consist of reinforcing of existing banks with fascines of brushwood, or with rubble, stone, concrete blocks, or rows of semicylindrical concrete bastions. Breakwaters of wooden piling filled with brushwood fascines and gravel are also used.

Useful additional sources of material:

ISTD/C/237. ISTD "C" Reports on Northern Italy, Topography, Inter Service Topographical Department, 1 September 1942. (Detailed study of the entire area.)

Kanter, Helmuth. Handbuch der Geographischen Wissenschaft, Südost and Südeuropa, 1931, pp. 289-416. (A general account of the entire country including helpful sketch maps and illustrations.)

Dainelli, Giotto. Atlante Fisico Economico d'Italia, Milano, 1940. (Excellent collection of maps illustrating physical and economic characteristics of Italy.)

General Staff, Geog. Section, 3902, Europe (Mr), Italy, 1940. Set of maps 1:250,000 showing topography, forested areas, communication routes, airfields, etc.

Carta d'Italia, 1:50,000, Instituto Geografico Militaire. Various years -- Topographic Maps of Italy.

CID/S/45040, Notes on Po Valley -- Allied Force Headquarters September 20, 1943. (A good account of relief, drainage, and canals, of the Po Valley.)

Strategic Engineering Study, No. 59, Terrain Intelligence, Italy. Intelligence Branch Office, Chief of Engineers, March 194[illegible]

Fischer, Theodor. La Penisola Italiana, Torino, 1902. (A comprehensive geographical description.)

Heybiggin, Marion Isabel. Southern Europe. (Excellent detailed regional and economic geography of the Mediterranean lands.)

Encyclopaedia Britannica, 1941. (Good basic source -- moderately detailed if subject headings are consulted.)

Longobardi, Cesare. Land Reclamation in Italy, 1936. (Many tables of data and a map of areas covered by the various projects. Also includes many speeches by Mussolini.)

Olon, Jules. Geographie Universelle, Italy. Vol. 7, part 2, pp. 235-394, 1934. (Good description with numerous illustrations and sketch maps.)

Ministero dei Lavori Pubblici, "Le Bonifiche Italiane, Anni Storici Tecnici e Statistici", 1925 and later dates. (Detailed accounts of river regimes, reclamation, and related topics.)

Tassinari, Giuseppe. La Bonifica Integrale Nel Decennale Della Legge Mussolini, 1933.

Thackleton, R.H. Europe, A Regional Geography, 1934. (Very good description of physical conditions of Italy.)

3. Climate.

a. Problems of Heat and Cold. Temperatures in the Po Plain throughout the year are similar to those of the east coast of the United States from New Jersey to North Carolina. For that reason, clothing and heating needs are similar in the two areas. Winters are damp and fairly cold in the Po Plain, averaging 32° to 39°F in January (Fig. 4). Temperatures are frequently below freezing at night, especially in the western half of the valley. In January, Venice (Venezia) has 13 days with minimum temperatures below freezing, while Turin (Torino) has 26 days (Fig. 5). Temperatures may drop to as low as 10°F in the east and 0°F in the west. In the east, winters are windy, especially at times when cold bora* winds blow from the north or northeast. In the west winters are generally calm.

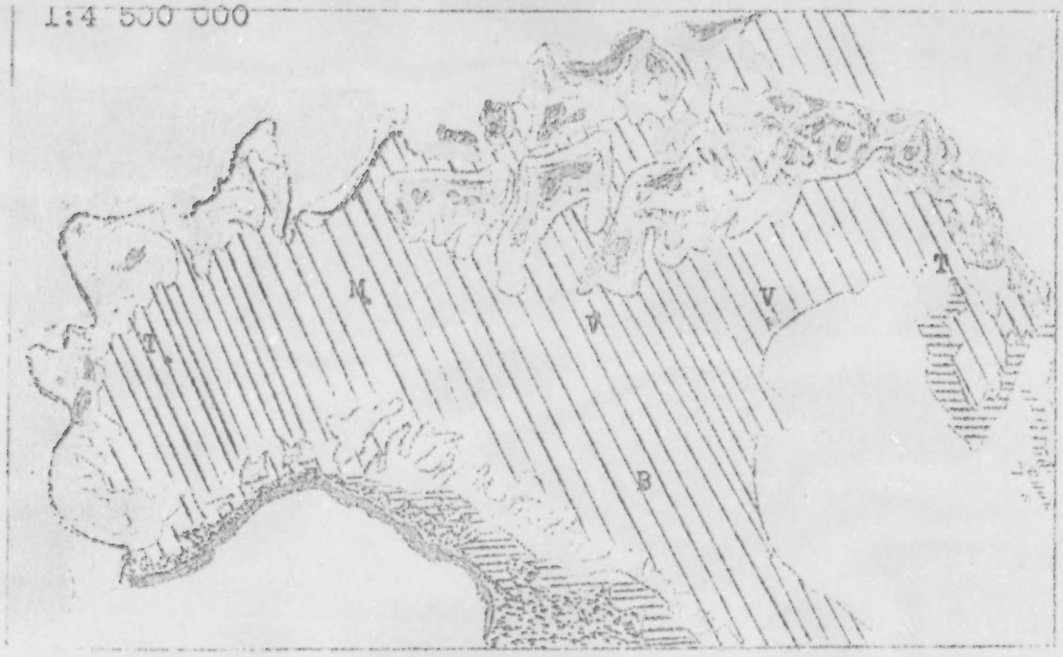
House heating and warm clothing are needed in winter. In the cities many houses have central heating, and coal is used; older houses have open fireplaces. If coal imports from Germany are stopped, it will be necessary to obtain coal from other sources. Few homes are heated by gas or electricity. In rural areas heating is done with wood, especially olive wood, which burns slowly. Overcoats are needed for outdoor wear in winter, and heavy underclothing is needed indoors because temperatures in houses are generally below 65°F.

Summers are hot, with mean temperatures in July from 75° to 82° (Fig. 6), but excessive heat is rare, and temperatures above 100° have not been recorded in most of the valley.

* The bora is a northerly wind which blows aperiodically, and often reaches a high velocity. It generally occurs when a high pressure center is over the continent. Low temperatures and clear skies accompany this wind.

Pl. I-4, 5.

4. Mean Temp., January.

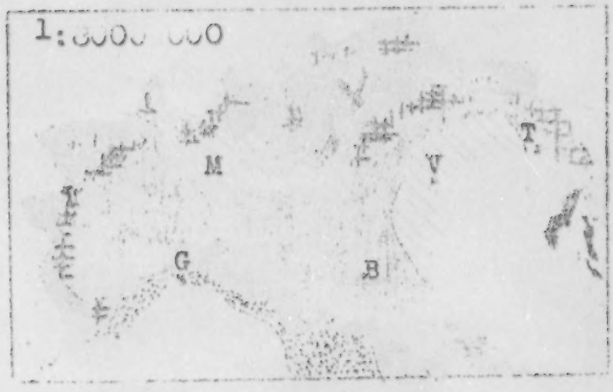


Legend

degrees F.

46-54
39-46
32-39
21-32
10-21
0-minus 11

5. Number of Days with Frost.



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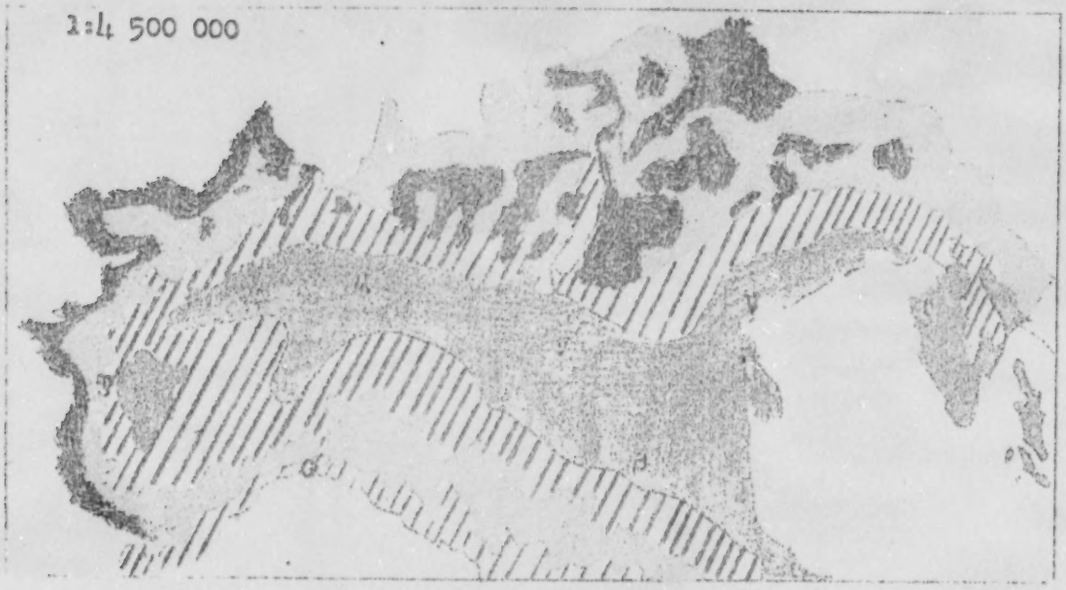
1-25
25-50
100-150
10-50
50-100
100-200

Fig. I-6,7.

6. Mean temp., July.



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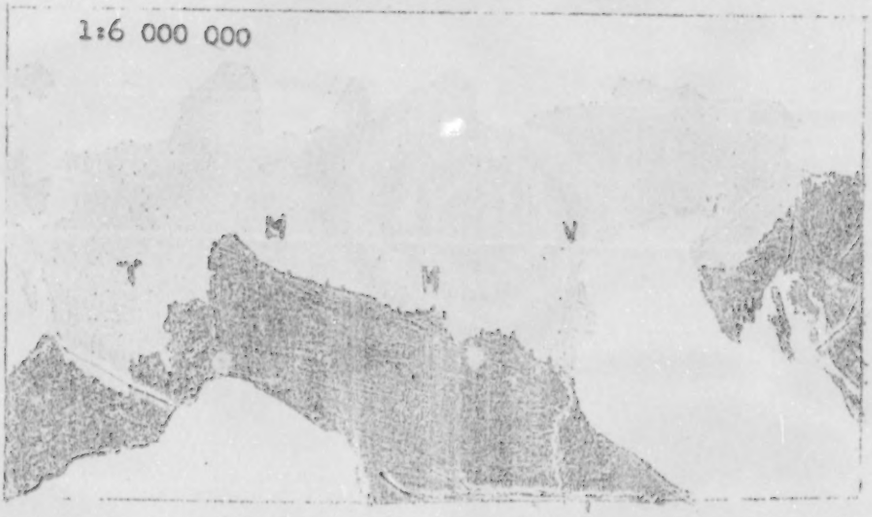
degrees F.

75-82
68-75
61-68
39-54

7. Precipitation Regimes



Legend

Minimum in winter
Minimum in summer

Along the coast of Istria, winter is moderately cold, averaging 39° to 46° in January, about like North and South Carolina. Istria has from 5 to 10 days a month in winter with cold, clear bora weather. Temperatures drop below freezing on about 10 days in January, and the lowest temperature on record is 14°F. Summers are very warm, with mean temperatures like those of the eastern United States from New York to Virginia, averaging 68° to 77°F in July. Unlike eastern United States, temperatures above 100° are seldom recorded.

The Ligurian coast is similar to the Gulf Coast of the United States in temperature. Winters are mild, averaging 46° to 54°F in January, though temperatures have dropped as low as 15°F during a severe cold spell. Summers are moderately hot, averaging 68° to 77°F in July. The high temperatures associated with southerly siroccos* in spring and summer may cause discomfort but they never rise as high as 100°F.

b. Climatic Limitations on Agriculture. Most of the Po Plain has its maximum precipitation in autumn and spring, while the summer season is relatively dry (fig. 7; also see precipitation maps in ICTD/C/238). Summer precipitation is generally sufficient only for crops of sub-humid types. Irrigation is therefore widely used to increase yields and to permit the growth of humid-land crops. Fluctuation in the amount of summer rain causes large variations in the yield of non-irrigated crops. The volume of irrigation water available generally depends on the precipitation regime (see section 2.d, Hydrography, above).

* The sirocco is a southerly wind which blows with moderate velocity. It generally occurs when a low pressure center passes directly over or to the north of a station. High temperatures, high humidity, and cloudy skies accompany this wind.

The flow of Alpine streams, however, is controlled by the melting of mountain snow; both Alpine stream flow and snow melting are at their maximum in June. Because of the greater amount of rainfall and of available irrigation water, the northern half of the Po Plain is most suitable for moisture-loving crops such as corn (maize).

Low temperatures and frost limit the growing season in the Po Plain to the period from about April to October. There are 50 to 100 days a year with frost in the Plain, except in a sheltered belt north of Milan along the base of the Alps with less than 50 days a year (fig. 5). The planting of summer grains such as rice and corn takes place from the beginning of April to the middle of May in normal years. Winter grains, such as wheat, rye, and barley, are planted from mid-September to early November. The time of planting in certain sections of the Plain is a week or two earlier or later than the dates mentioned. In Liguria corn planting begins in mid-March, and wheat planting begins in mid-September. In case of seed shortages, supplies would have to be made available several weeks in advance.

In Istria the milder climate permits the raising of crops of Mediterranean types, but the dry soil resulting from the porous limestone bedrock seriously restricts agriculture.

The Ligurian coast has mild, rainy winters with only occasional frost, and hot, dry summers. The narrow coastal plain limits agriculture to a small area where typical Mediterranean crops are grown.

c. Climatic Restrictions on Road Traffic. Highway traffic in the Po Plain is only occasionally hampered by climatic elements. In most years, snow cover does not become deep enough to disrupt traffic, but cities in the northern Po Plain own some snow-removal equipment. Glaze, which results from rain falling when surface temperatures are below freezing, is too rare to be a major traffic hazard. Floods, caused by excessive rains or by the sudden melting of snow, occasionally block traffic (see Section 2.d, Hydrography). Fog is widespread in lowlands in winter, and is often dense enough to slow up traffic. At Milan almost half the mornings and one out of five afternoons in winter have visibility of less than a quarter of a mile. Fog is infrequent from April to September.

In the Alps the major handicap to highway traffic is snow. In general, the period of snow blocking becomes longer with increasing altitude. As a result, most of the lower Alpine passes (below 6000 feet) can be kept open throughout the year, while the higher passes, such as St. Bernard and St. Gotthard, are blocked for 7 or 8 months (from October to May or June). Alternate freezing and thawing in autumn and spring cause rockfalls and avalanches which may block roads.

Along the Ligurian coast, floods are the only weather hazards which hamper traffic on good roads. Floods are generally caused by excessive rains during the cooler half of the year. In the Apennines, the principal highways are seldom blocked by snow.

d. Climatic Restrictions on Air Traffic. Air traffic over the Po Plain is restricted frequently in the cooler half of

the year (see valuable analysis and map in ISTD/C/238). The most important limiting factor is the widespread fog, which reduces visibility to less than half a mile. In December and January about two-thirds of the mornings and half the afternoons have fog. Turbulence of the atmosphere also occasionally handicaps flying, though the western half of the Po Plain generally has quiet weather in winter. The eastern half is windier, and experiences the strong, gusty bora winds. Cloud also restricts flying at times. Ceilings at Milan are below 3000 feet on half the days from November to February. Mean cloud cover during this period is 60 to 70 percent of sky covered (fig. 8).

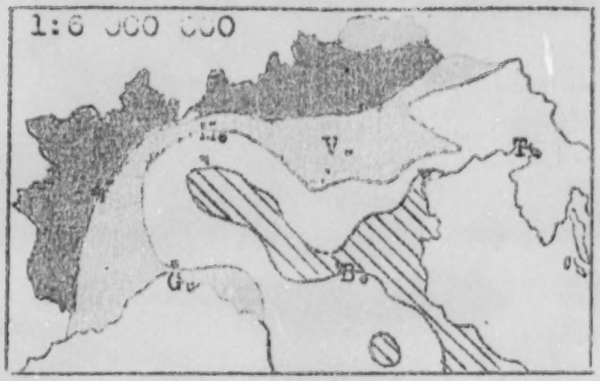
Summer weather conditions in the Po Plain are favorable most of the time for flying. Fog occurs on only a few days a month. Turbulence is more frequent than in winter over the Plain and the Alps, as convection and thunderstorms are common from May to September. The worst turbulence over the Alps occurs near the Austrian frontier, where thunderstorms are most frequent. The cloud ceiling at Milan is below 3000 feet on less than 10 days a month from March to October. Mean cloud cover is 30 to 40 percent (fig. 9).

In Istria wind velocity is probably the greatest handicap to flying in winter. Strong, gusty east or northeast boras blow on 5 to 10 days a month. These winds generally bring low temperatures and clear skies. The Gulf of Trieste has an average of 7 days in January with winds over 30 mph., mostly bora. Fog is a less important limiting element; Trieste has

Fig. I-8,9.

Cloud Cover.

8. Winter



Legend

Percent of sky covered.

20-30
30-40
40-50
50-60
60-70

9. Summer.

fog on 4 to 6 days a month from November to March. Mean cloudiness is 50 to 60 percent.

In summer, weather conditions are generally good for flying in Istria. Wind velocities are relatively low, visibility is very good, and skies are generally clear, except for occasional heavy thunderstorms and turbulence. Mean cloud cover is 30 to 45 percent. Occasional southerly sirocco winds cause low clouds in spring and summer.

In the Ligurian coastal area, weather restricts flight on only a few days per month, even in the cooler half of the year. During that time Genoa has fog on only 2 days per month. Ceiling is below 3000 feet on 10 to 13 days a month in winter, and cloud cover is 40 to 55 percent. In December there are 5 days with winds over 30 mph., most of them from the North. In summer, conditions are even better for flight. Genoa has only 6 to 10 days per summer month with ceiling below 3000 feet, and mean cloud cover is from 30 to 45 percent. Winds are light and variable during this season.

For additional information, consult the following:

ISTD/C/238. ISTD "C" Reports on Northern Italy, Climate and Medical, Inter-Service Topographical Department, 1 September 1943. (A fairly complete and adequate study.)

Weather Information Branch, Headquarters, Army Air Forces, General Climatic Information Guides, Washington, D.C.
No. 5, Climate of Genoa, July 1943.
No. 14, Climate of Venice, August 1943.
No. 15, Climate of Turin, August 1943.
No. 18, Climate of Trieste, September 1943.
(Useful detailed descriptions of the climates of various localities

War Advisory Council on Meteorology. Weather Guide for Long Range Planning. For Milan, Italy, Washington, D.C., 1943.

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Dainelli, Giotto. Atlante Fisico Economico d'Italia, Milano, 1940, maps 10 to 20. (A valuable series of maps of the various climatic elements.)

U.S. Department of Commerce, Weather Bureau. Occurrence of Various Ceiling Heights and Visibility Limits for Western Europe. (Includes data for Milan and Genoa.)

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4. Vegetation. The general features of the vegetation are indicated in Figure 10.

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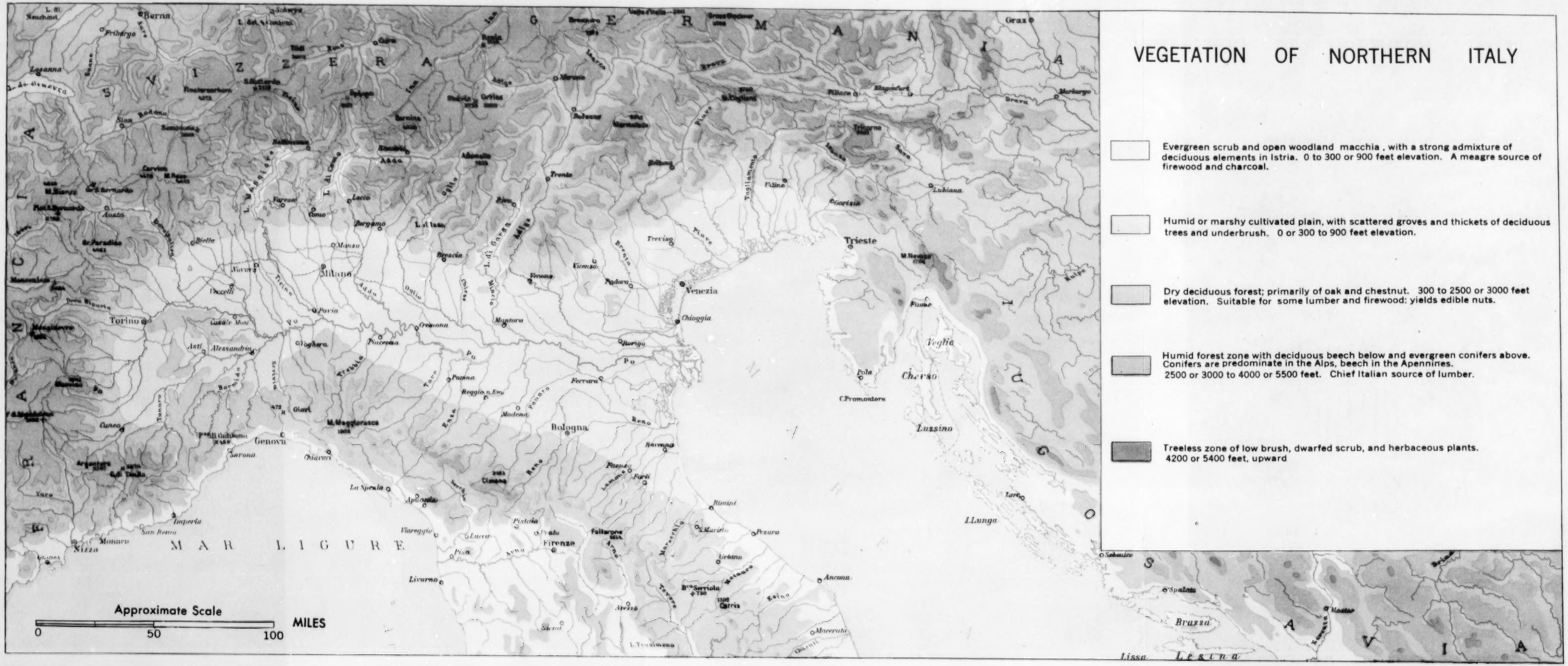
FIGURE I-10

FREE



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